



PCT/EP2004 / 050245



INVESTOR IN PEOPLE

The Patent Office
Concept House
Cardiff Road
Newport
South Wales
NP10 8QQ

EPO - DG 1

15. 03. 2004

(51)

REC'D 05 MAY 2004

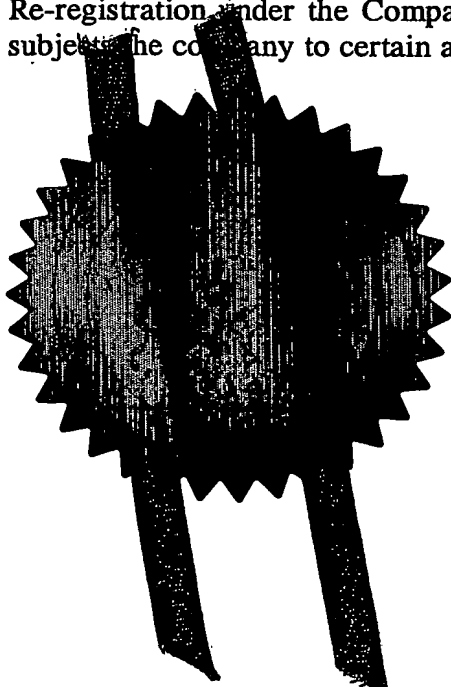
WIPO PCT

I, the undersigned, being an officer duly authorised in accordance with Section 74(1) and (4) of the Deregulation & Contracting Out Act 1994, to sign and issue certificates on behalf of the Comptroller-General, hereby certify that annexed hereto is a true copy of the documents as originally filed in connection with the patent application identified therein.

In accordance with the Patents (Companies Re-registration) Rules 1982, if a company named in this certificate and any accompanying documents has re-registered under the Companies Act 1980 with the same name as that with which it was registered immediately before re-registration save for the substitution as, or inclusion as, the last part of the name of the words "public limited company" or their equivalents in Welsh, references to the name of the company in this certificate and any accompanying documents shall be treated as references to the name with which it is so re-registered.

In accordance with the rules, the words "public limited company" may be replaced by p.l.c., plc, P.L.C. or PLC.

Re-registration under the Companies Act does not constitute a new legal entity but merely subjects the company to certain additional company law rules.



**PRIORITY
DOCUMENT**

SUBMITTED OR TRANSMITTED IN
COMPLIANCE WITH RULE 17.1(a) OR (b)

Signed

Dated

P. McHenry
25 November 2005

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

THE PATENT OFFICE
J
28 MAR 2003
NEWPORT

The Patent Office

Cardiff Road

Newport

Gwent NP9 1RH

1. Your reference

CE31023P/LML/GBRI/VC/STEPHENS

2. Patent application number

(The Patent Office will fill in this part)

0307153.7

28 MAR 2003

3. Full name, address and postcode of the or of each applicant (underline all surnames)

MOTOROLA, INC
1303 EAST ALGONQUIN ROAD,
SCHAUMBURG, ILLINOIS 60196,
U.S.A.

Patents ADP number (if you know it)

08281107001

If the applicant is a corporate body, give the country/state of its incorporation

U.S.A.

DELAWARE

4. Title of the invention

METHOD FOR DETERMINING A COVERAGE AREA IN A CELL-BASED COMMUNICATION SYSTEM

5. Name of your agent (if you have one)

LITCHFIELD LAURA

"Address for service" in the United Kingdom to which all correspondence should be sent (including the postcode)

EUROPEAN INTELLECTUAL PROPERTY DEPARTMENT
MIDPOINT
ALENCON LINK
BASINGSTOKE
HAMPSHIRE RG21 7PL
UK
ADP NO. 00001180006

Patents ADP number (if you know it)

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and (if you know it) the or each application number

Country

Priority application number
(if you know it)

Date of filing
(day / month / year)

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application

Date of filing
(day / month / year)

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? (Answer 'Yes' if:

☒ YES ☐ NO

a) any applicant named in part 3 is not an inventor, or

b) there is an inventor who is not named as an applicant, or

c) any named applicant is a corporate body.

See note (d))

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form

Description 22

Claim(s) 6

Abstract 1

Drawing(s) 3

10. If you are also filing any of the following, state how many against each item.

Priority documents //

Translations of priority documents

Statement of inventorship and right to grant of a patent (Patents Form 7/77) 4

Request for preliminary examination and search (Patents Form 9/77) 1

Request for substantive examination (Patents Form 10/77) 1

Any other documents 1 x FEE SHEET
(please specify)

11.

I/We request the grant of a patent on the basis of this application.

Signature

Litchfield

Date

26/3/03

12. Name and daytime telephone number of person to contact in the United Kingdom

LITCHFIELD LAURA

Vanessa CUTT

01256-790264

Warning

After an application for a patent has been filed, the Comptroller of the Patent Office will consider whether publication or communication of the invention should be prohibited or restricted under Section 22 of the Patents Act 1977. You will be informed if it is necessary to prohibit or restrict your invention in this way. Furthermore, if you live in the United Kingdom, Section 23 of the Patents Act 1977 stops you from applying for a patent abroad without first getting written permission from the Patent Office unless an application has been filed at least 6 weeks beforehand in the United Kingdom for a patent for the same invention and either no direction prohibiting publication or communication has been given, or any such direction has been revoked.

Notes

- If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.
- Write your answers in capital letters using black ink or you may type them.
- If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.
- If you have answered 'Yes' Patents Form 7/77 will need to be filed.
- Once you have filled in the form you must remember to sign and date it.
- For details of the fee and ways to pay please contact the Patent Office.

METHOD FOR DETERMINING A COVERAGE AREA IN A CELL-BASED COMMUNICATION SYSTEM

Field of the Invention

5

This invention relates to determining the coverage area of a cell in a cell-based communication system. The invention is applicable to, but not limited to, utilising such coverage area information to assist alarm

1 0 prioritisation due to cell outage and/or re-configure a system's or cell's operational parameters to minimise the degree of overlapping coverage, thereby allowing higher capacity/quality frequency plans to be deployed.

1 5 Background of the Invention

Wireless communication systems, for example cellular telephony or private mobile radio communication systems, typically provide for radio telecommunication links to be

2 0 arranged between a plurality of base transceiver stations (BTSs) and a plurality of subscriber units, often termed mobile stations (MSs).

In a wireless communication system, each BTS has

2 5 associated with it a particular geographical coverage area (or cell). Primarily, a particular transmitter power level defines a coverage area where a BTS can maintain acceptable communications with MSs operating within its serving cell. In addition, receiver

3 0 sensitivity performance of receiving wireless communication units also affects a given coverage area. In large cellular communication systems, these cells are

combined and often overlapped to produce an extensive coverage area.

5 Wireless communication systems are distinguished over fixed communication systems, such as the public switched telephone network (PSTN), principally in that mobile stations move between coverage areas served by different BTS (and/or different service providers) and, in doing so, encounter varying radio propagation environments.

1 0

In a cellular system, adjacent cells are typically configured to overlap, to ensure a contiguous signal coverage area. The cell overlap region is deliberately designed into the system plan to ensure that mobile stations can successfully handover between cells. The degree of coverage overlap between cells can vary enormously. In such systems it is desirable to have an accurate measure of unique cell coverage (and ideally cell overlap) to operate and maintain the network more effectively (i.e. maximising capacity and quality of service).

1 5

2 0

A system design based on cells is typically based on an ideal cell pattern. However, an idealised cell pattern never occurs in practice, due to the nature of the terrain and the fact that cell sites and antennae are not ideally located on a regular grid pattern. The network designer therefore uses frequency planning tools to estimate the radio propagation for each cell and predict a corresponding coverage area. Based on these propagation models, the network designer is able to develop a frequency plan for the network intended to minimise the expected interference. The frequency plan

2 5

3 0

considers such factors as antenna heights and location, terrain topology, transmitted power levels and the anticipated number of subscribers.

5 By collating predicted coverage area information for a number of cells, it is possible to determine a degree of coverage overlap between a number of respective cells. However, the accuracy of these tools is limited, since they 'predict' the theoretical coverage rather than
1 0 measure the actual coverage supported by a particular BTS.

The quality of a frequency plan that can be produced by such coverage prediction techniques is constrained by the
1 5 degree of coverage overlap between cells. Greater overlap means greater potential interference, making it more difficult to produce a low interference frequency plan. A traditional method of allocating frequencies in a wireless cellular system is to employ a channel
2 0 allocation algorithm in conjunction with a carrier-to-interference (C/I) matrix, where the C/I matrix may use measurement report data.

Achieving an optimum frequency plan is therefore
2 5 dependent on the C/I matrix accuracy, and it is inaccuracies in these matrices that ultimately lead to unexpected interference. There are a number of reasons why traditionally produced matrices are inaccurate. For example, the matrices are based on predicted interference
3 0 levels at ground level, i.e. subscribers in high buildings are not considered. They assume fixed cell boundaries whereas the characteristics of MSs and handover algorithms are such that cell boundaries can

move. Also, they are reliant on accurate site and antenna data. This data can be far from accurate with some Operators having no clear idea of where their sites are, let alone being confident in the bore angles of the
5 antennas. They do not reflect the impact of detailed clutter data, such as street canyons.

Furthermore, these coverage prediction techniques tend to focus on geographic coverage area, assuming an even
1 0 distribution of MSs within the cell, rather than subscriber-based coverage where subscribers are unevenly distributed across a cell. This inaccuracy limits the effectiveness of the predictions and the resulting decisions made therefrom. This, in turn, means that the
1 5 network is sub-optimally configured and therefore typically delivers a sub-optimal quality of service.

The inventors of the present invention have therefore both recognised and appreciated that there is currently
2 0 no accurate method of determining an accurate cell-based coverage map, particularly when there exists coverage overlap between cells.

In the context of network optimisation, it is known that
2 5 measurement reports are collected from an operational network, as described in co-pending UK Patent Application GB 9926513.4 having the same Applicant as the present invention. The data collected is then analysed to generate neighbour cell list for handover purposes and
3 0 facilitate power control decisions. In this regard, it is known that MSs scan signal transmissions from multiple BTSs and report the signal levels of these in the measurement reports. The scanning process, which is used

to generate the measurement reports, enables the MS (or its serving BTS) to determine optimal handover candidates, namely the BTS offering the highest quality signal/communication link to the respective MS.

5

Thus, there exists a need in the field of the present invention to provide a cell-based communication system and method for determining coverage overlap in a cell-based communication system, wherein the aforementioned disadvantages may be alleviated.

1 0

Statement of Invention

In accordance with a first aspect of the present invention there is provided a method of determining a coverage area in a cellular communication system, as claimed in Claim 1.

1 5

In accordance with a second aspect of the present invention, there is provided a storage medium, as claimed in Claim 11.

2 0

In accordance with a third aspect of the present invention, there is provided a communication system, as claimed in Claim 12.

2 5

In accordance with a fourth aspect of the present invention, there is provided a communication unit, as claimed in Claim 13.

3 0

In accordance with a fifth aspect of the present invention, there is provided a communication unit, as claimed in Claim 14.

In summary, the inventive concepts of the present invention propose a mechanism for using measurement reports (MRs) to determine the unique coverage area and the potential interfering (overlapping) coverage generated by each cell, preferably determined in terms of Erlangs. By utilising MRs in this manner, the Network Operator is able to direct and prioritise both automatic and manual maintenance and optimisation activities, for example, alarm prioritisation to distinguish the more critical coverage areas. Alternatively, or in addition, the coverage area calculations, according to the preferred embodiment of the present invention, may be used to re-configure a system's operational parameters, such as: transmit power, a beam-forming antenna tilt or direction, and even turning off cell sites whose excessive coverage overlap provides unacceptable interference or severely restricts the frequency allocation process.

Brief Description of the Drawings

Exemplary embodiments of the present invention will now be described, with reference to the accompanying drawings, in which:

FIG. 1 illustrates a block diagram of a cellular radio communications system adapted to support the various inventive concepts of a preferred embodiment of the present invention;

FIG. 2 illustrates a cell-based communication system adapted to support the various inventive concepts of a preferred embodiment of the present invention; and

5 FIG. 3 illustrates a flowchart of a method of determining an overlapping coverage area, and thereafter utilising such information, in accordance with a preferred embodiment of the present invention.

1 0 Description of Preferred Embodiments

The inventive concepts of the present invention propose a mechanism for using measurement reports (MRs) to determine both the unique and overlapping (and therefore
1 5 interfering) coverage areas generated by each cell. In particular, three aspects of a respective cell's coverage may be determined:

(i) The amount of traffic that receives coverage uniquely from this cell;

2 0 (ii) The amount of traffic that receives coverage from this cell, but which could also obtain coverage from an adjacent cell; and

(iii) The amount of traffic carried by adjacent cells that could provide coverage to this cell.

2 5

From a perspective of a serving cell, at one extreme, it is known that the coverage area of the cell may be completely overlapped by one or more adjacent cells. At the other extreme, the coverage area of two cells may be
3 0 configured to not overlap at all. This variation has significant implications for system operation. For example, if a cell goes off-air, then subscriber units in the area uniquely covered by this cell will no longer

have service. However, if there is a large degree of overlap from neighbouring cells, then many subscriber units will be able to receive service from neighbouring, but less-preferred, cells. Conversely, with no overlap,
5 all subscriber units will lose service.

Hence, in accordance with a preferred embodiment of the present invention, a mechanism to determine an accurate knowledge of coverage overlap is proposed. Once an
1 0 accurate knowledge of coverage overlap has been determined the relative importance of keeping various cells on air can be identified.

The inventors of the present invention have appreciated
1 5 that those cells providing the most unique coverage are the most critical to be maintained. Therefore, for example in a first embodiment of the present invention, the resulting cell outage alarm should be set to reflect the uniqueness and importance of the coverage area.
2 0 Furthermore, in a second embodiment of the present invention, such knowledge also helps determine network availability as well as enabling a Network Operator to set optimum system parameters. Furthermore, such knowledge enables higher capacity and better quality
2 5 frequency plans to be deployed.

From a perspective of a neighbouring, overlapping cell, at one extreme, the cell may overlap with many neighbouring cells. Alternatively, the cell may overlap
3 0 with no other cells. This variation impacts frequency planning, since the frequencies assigned to a cell with large overlap cannot be re-used in the overlapped cells, making frequency planning more difficult. However, a

cell with a large overlap may be useful for providing continuity of service, should the overlapped cells go out of service or become congested.

5 The inventive concepts of the present invention alleviate the aforementioned problems associated with the coverage prediction by extending the concept of an Intelligent Optimisation Service (IOS), as described later. In particular, the present invention proposes a mechanism of
1 0 using existing measurement reports to assist in determining a level of coverage overlap. Furthermore, once such measurement reports have been received and processed and coverage overlap information has been calculated, the information can be used in a variety of
1 5 ways, as detailed later.

Referring first to FIG. 1, a cellular telephone communication system 100 is shown, in outline, supporting a Global System for Mobile communication (GSM) air-
2 0 interface, in accordance with a preferred embodiment of the invention. The European Telecommunications Standards Institute (ETSI) has defined the GSM air-interface.

Generally, the air-interface protocol is administered
2 5 from base transceiver sites, within the network architecture 110, that are geographically spaced apart - one base site supporting a cell (or, for example, sectors of a cell), as shown in FIG. 2.

3 0 A plurality of subscriber units 112-116 communicate over the selected air-interface 118-120 with a plurality of base transceiver stations (BTS) 122-132. A limited number of MSs 112-116 and BTSs 122-132 are shown for

clarity purposes only. The BTSs 122-132 may be connected to a conventional public-switched telephone network (PSTN) 134 through base site controllers (BSCs) 136-140 and mobile switching centres (MSCs) 142-144.

5

Each BTS 122-132 is principally designed to serve its primary cell, with each BTS 122-132 containing one or more transceiver units and communicating 156-166 with the rest of the cellular system infrastructure

1 0

Each BSC 136-140 may control one or more BTSs 122-132, with BSCs 136-140 generally interconnected through MSCs 142-144. Processes within the MSCs are provided to account for the situation where a MS (112-116) passes

1 5

between two BTS serving areas, for example MS 112 moving from an area covered by BTS 122 to an area covered by BTS 124, where the two BTSs are controlled by different BSCs (BSC 136 and BSC 138 in this example).

2 0

Similar processes are supported in MSCs to account for the situation where an MS moves between serving BTSs where these BTSs are connected to different MSCs. These mechanisms therefore allow the cellular telephone communication system to support handover of MSs 112-116 between overlapping cells in a contiguous, seamless manner.

2 5

3 0

Each MSC 142-144 provides a gateway to the PSTN 134, with MSCs 142-144 interconnected through an operations and management centre (OMC) 146 that administers general control of the cellular telephone communication system 100, as will be understood by those skilled in the art.

The various system elements, such as BSCs 136-138 and OMC 146, include control logic 148, 150, 152, with the various system elements usually having an associated memory function 157 (shown only in relation to OMC 146 for the sake of clarity). A memory function 157 of the OMC 146 typically stores historically compiled operational data as well as in-call data, system information such as neighbouring cell-site lists and control algorithms such as a list of frequencies to be scanned by the respective MSs.

In accordance with the preferred embodiment of the present invention, the OMC or an optimisation function adjunct to the OMC 146 receives Measurement Reports (MR) collected from respective cells, either from, say, serving BTSs and/or served MSs. In the context of the present invention, it is envisaged that an OMC's handling of MRs may be complemented or replaced by any such adjunct optimisation function. As such, the following description of the OMC's functionality in this regard encompasses any such suitable configuration. Notably, the OMC 146 has been adapted to include an overlapping coverage area mapping/calculation function 155. The overlapping coverage area mapping/calculation function 155 utilises the MR data to determine those cells that provide a unique coverage to MSs within those cells. The overlapping coverage area mapping/calculation function 155 also utilises the MR data to determine those cells where some coverage can be supported by neighbouring cells.

In this regard, the OMC is able to calculate an amount of overlapping coverage area. The OMC 146 has been

configured to receive any operational/ environmental data provided by the system elements or UEs relating to the operational characteristics of the respective cells, in order to determine, for example, a level of unique coverage that respective cells provide.

In a further enhanced embodiment of the present invention, one or more BSCs 136 and/or one or more BTSs 122 may include, or be operably coupled to, an MR agent (not shown). The BSC 136 or BTS 122 preferably configures the agent to seek out and record measurements for the requisite environmental or operational data that may affect the overlapping coverage area of the cell.

It is also envisaged that the cell's MR information may be sent from any number of sources and include any useful data. In particular, the information may include:

(i) Cell statistical information, available at the OMC, such as Congestion, Blocking, Mean-Hold Time (MHT), Handover (HO) Cause distribution;

(ii) Measurement Reports, which indicate the Radio Frequency (RF) environment of the subscriber units; or

(iii) Control Signalling behaviour. This information is readily available to the OMC function in existing systems. It forms the basis of reports generated for the Network Operator to analyse during the course of normal operational activities.

In particular, if a MR from a MS contains no neighbouring BTS measurements, or only very weak neighbour measurements, it can be assumed that the MS could not achieve service from any neighbouring cell. This

information is particularly useful to the OMC 146, should that serving cell go off-air or become congested.

Conversely, if the MR contains one or more neighbour measurements indicating a strong received signal, then it can be assumed that the MS could obtain service from one of these neighbours, if its serving cell becomes unavailable. Thus, by analysing all the MRs collected from a particular cell, it is possible to determine, for example, a proportion of the cell's traffic that depends solely on that cell for service. In this context, the OMC 146 is able to determine a unique coverage factor for that cell (UCF), where:

$$\text{UCF} = \frac{\text{Sum of MRs with no/weak neighbours}}{\text{Total Sum of MRs}} \quad [1]$$

In the context of the present invention, a weak neighbour is defined, for example, as a neighbour reported with a received signal level (RXLEV) of < 'X', where 'X' can be set by the Network Operator, for example, set at an RXLEV of '10' (equivalent to, say, -100dBm).

In the enhanced embodiment of the present invention, the OMC 146 comprises an overlapping coverage area mapping/calculation function 155 to generate/calculate a subscriber-based coverage map that particularly indicates coverage overlap areas.

Preferably, the calculation to determine the degree of overlapping coverage is based on the number of times that a cell is reported as a neighbouring cell, by subscriber units in the other network cells. Indeed, in accordance

with the preferred embodiment of the present invention, this information can easily be extracted from existing measurement report information. In this regard, a carrier-to-interference (C/I) matrix of rows and columns is produced, where each column represents the potential interference generated by a specific cell.

A simplified example of such a matrix is illustrated below in Table 1. The rows represent the cells 'A'-'D' as serving cells, and the columns represent cells 'A'-'D' as interfering cells. For example, cell 'B' can expect to lose six Erlangs of traffic due to interference, if it has the same frequency as cell 'C'. Hence, the amount of coverage overlap generated by each cell, which could potentially lead to interference, is represented by the total of the column for the respective cell. Thus, in this example, Cell 'B' has the highest overlap with forty Erlangs of traffic seen in other cells at a strong level.

Table 1:

	A	B	C	D
A		10	5	10
B	12		6	10
C	5	15		17
D	7	15	5	
Total	24	40	16	37

Advantageously, the use of Measurement Reports ensures that 'real' measurement data from the actual operating network is used, in contrast to the known technique of using inaccurate prediction data. By ensuring that a statistically significant volume of Measurement Reports are used in the calculations, it is possible to guarantee that the resulting measures or calculations of unique

cell coverage and cell overlap are extremely accurate. These values represent the cell coverage and overlap from the perspective of all the network subscriber units. Consequently, the impact on the network subscriber units, of decisions made using this data, can be accurately determined.

In accordance with the preferred embodiment of the present invention, the memory element 157 of the OMC 146 has also been adapted to include, for example, a look-up table of the coverage overlap information. In this regard, the look up table contains information relating to one or more of the following:

- (i) Cell operational parameters,
- (ii) Threshold values used in the respective cell(s),
- (iii) Traffic profile information for that cell,
- (iv) Received signal level information, say from a number of MSs, for that cell - irrespective of whether the MSs are being currently served in that cell, or
- (v) Transmitter power information, for either BTS and/or MS, relating to a particular cell.

Although the inventive concepts of the present invention have been described with regard to an implementation in an OMC 146, it is within the contemplation of the invention that the overlapping coverage area mapping/calculation function 155 may be provided in a separate device or function, operably coupled to the OMC 146. Alternatively, the overlapping coverage area mapping/calculation function 155 may be located within any other element within the infrastructure, such as MSCs 142, 144, or within BSCs 136, 138, 140 or even

distributed within a number of elements, if appropriate.
For example, the overlapping coverage area
mapping/calculation function 155 could be implemented
within the radio access network (RAN) of the cellular
5 infrastructure equipment and/or it may be implemented as
a stand-alone element/function on an adjunct platform.
Indeed, it is envisaged that the OMC as a logical entity
could comprise several distributed or substantially co-
located boxes with specific functions, including an
1 0 optimisation (IOS) box.

In a preferred embodiment of the present invention, it is
also envisaged that one or more BTSs 122-132 and/or one
or more BSCs 136-140 may be adapted to regularly or
1 5 intermittently collect the MR data. This information
would then be forwarded to the OMC 146 (or indeed any
other associated element) where the overlapping coverage
area mapping/calculation function 155 resides.

2 0 More generally, an overlapping coverage area
mapping/calculation function 155 may be programmed into,
say, the OMC 146 according to the preferred embodiment of
the present invention, in any suitable manner. For
example, new apparatus may be added to a conventional
2 5 communication unit (for example OMC 146). Alternatively
existing parts of a conventional communication unit may
be adapted, for example, by reprogramming one or more
processors therein. As such the required adaptation may
be implemented in the form of processor-implementable
3 0 instructions stored on a storage medium, such as a floppy
disk, hard disk, programmable read only memory (PROM),
random access memory (RAM) or any combination of these or
other storage media.

Referring now to FIG. 2, a cell-based communication system 200, adapted to support the various inventive concepts of a preferred embodiment of the present invention, is illustrated. FIG. 2 is a representation of, say, a street level coverage map from Cells A 210, B 220, C 230, D 240, E 250, F 260 and X 270. As with a vast majority of cell-based wireless communication systems, there is significant degree of overlap between cell coverage areas. A key illustration in FIG. 2 is that although the coverage area of Cell X 270 is significant, most of its coverage could be supplemented by coverage from neighbouring cells 'A' to 'F' 210-260. The proportion of unique coverage that is solely supportable by cell X 270 is an island of coverage at the centre of cell X 270. Any subscriber units located in this region would definitely suffer a complete outage if Cell X 270 were to go out of service.

Although FIG. 2 illustrates the geographical coverage impact of such an outage, a key benefit of the present invention is to determine a number of Erlangs of traffic that would be lost due to the outage. For example, let us assume that only 10% of the cell's coverage area is uniquely served by this cell.

However, if all the subscriber units in the cell are concentrated in this one small central area, then the impact of a cell outage will be to remove service from 100% of the cell's traffic, not just 10% that relates to the geographical impact. Thus, it is the Erlang value related to impacted traffic that is preferably used in, for example:

- (i) Prioritising a resulting outage alarm, and/or
- (ii) Re-configuring a system's operational parameters.

5 In an enhanced embodiment of the present invention, the potential interference generated by cell X 270 on neighbouring cells 'A'-'F' 210-260, based on a level of overlap between the cells, may be used to determine whether to re-configure cell X's operational parameters.

1 0 For example, the transmit power of cell X 270 may be reduced, or antenna down-tilting of Cell X's beam-forming antenna introduced.

Referring now to FIG. 3, a flowchart 300 illustrates an overview of the preferred overlapping coverage area measurement process. The flowchart commences with an OMC (or other box) collecting a series of Measurement Reports (MRs), for example resulting from a subscriber unit polling operation, as shown in step 305. MRs are

1 5 collected from the target cell and from its neighbouring cells.

2 0

These MRs are then separated into, say, three categories, in step 310:

- 2 5 (i) Those MRs for which an alternative cell is identified as being able to provide coverage;
- (ii) Those MRs for which there is no alternative coverage option, i.e. the subscriber unit generating the MR can only be served by that cell in that location; and
- 3 0 (iii) Those MRs collected from neighbouring cells that show a strong level of coverage from the target cell.

The OMC then converts the MR information into Erlangs, in step 315, to determine the traffic impact, rather than the geographical impact, of any potential cell outage. These results may then be stored, in step 325, according to the time of day, day of the week, month and any additional cell parameter information such as transmit power, and subscriber unit information such as cell location (say, from a GPS unit). In the illustrative step 325, the results are stored against four-hour intervals for each day of the week: however clearly the results may be stored using any storage/sorting method determined by a skilled person.

Thus, in this manner, an OMC determines how much traffic coverage is uniquely provided by a particular cell, for example, using existing measurement report data. Preferably, a statistically valid sample of MRs is used in the determination of an overlapping and/or unique coverage area. Once an Erlang figure has been determined, this figure is used to influence the Network Operator (or the OMC) to improve the network's performance.

For example, the figure is used to determine an appropriate cell outage strategy, in step 330. It is envisaged that such a use may entail determining when and how to maintain a cell, i.e. by turning the cell off. The traffic impact of such cell maintenance can therefore be minimised. Furthermore, the cell outage strategy may encompass the OMC using the Erlang value of uniquely covered traffic to select an alarm priority setting for the cell, as shown in step 340.

Advantageously, the unique coverage capability and coverage overlap information of the cell can also be used to automatically re-configure operational parameters in a cell, as shown in step 335. Such a re-configuration of operational parameters helps determine and implement a feasibility of beam-forming changes such as down-tilts, provision of additional redundancy, etc.

The inventive concepts of the present invention utilise dynamic monitoring and adaptation of a cell's operational parameters. Such information, when obtained extensively throughout the system, may be assessed to better plan and utilise available communication resources (frequencies) throughout the system. In this manner, it is envisaged that an automatic frequency planning operation may benefit from the inventive concepts described herein.

It is within the contemplation of the invention that the OMC 146 may use any additional indicia, such as traffic load, time of day, etc. to enhance the assessment of communications within the communication system. It is also envisaged that the OMC 146 (or other element) may poll BTSs or MSs within the system to obtain such additional indicia. Further variations that fall within the inventive concepts herein described will be apparent to a person skilled in the art.

The preferred embodiment of the present invention has been described with regard to a cellular telephony communication system, such as the global system for mobile communications (GSM). It is envisaged that the invention is equally applicable to other wireless communication systems, such as a universal mobile

telecommunication system (UMTS), any code division multiple access (CDMA) or time division multiple access (TDMA) system, or an integrated digitally enhanced network (iDEN)[™] as supplied by Motorola[™]. It is also
5 within the contemplation of the invention that alternative radio communication architectures, such as private or public mobile radio communication systems could benefit from the inventive concepts described herein.

1 0

It will be understood that the communication system, communication unit, and improved method for coverage prediction, as described above, provides at least some of the following advantages that could not be reliably
1 5 obtained using existing coverage prediction methods:

(i) Cells with high unique cell coverage are recognised as such, and may be managed more carefully. For example, a Network Operator may decide to introduce
2 0 additional equipment redundancy into a particular system to minimise the risk of cell outage.

(ii) Cells with low unique cell coverage can be configured to receive less attention. In some cases, if
2 5 capacity is not required, it may even be desirable to switch the cell off.

(iii) The aforementioned principles can be extended to encompass the level of unique coverage
3 0 provided by a group of cells (e.g. a BSC area), or the level of unique coverage provided by a particular sub-layer or frequency band (e.g. a Micro-cell layer, or a cellular 1800 MHz frequency band)

(iv) Cells that provide high levels of coverage overlap provide severe constraints on the development of a high quality and capacity frequency plan.

5 Consequently, these cells can be examined to determine whether the cell's transmit power can be reduced, the antenna down-tilted, or the cell completely switched off.

1 0 Whilst the specific and preferred implementations of the embodiments of the present invention are described above, it is clear that a skilled artisan could readily apply variations and modifications of such inventive concepts.

1 5 Thus, a communication system, a communication unit, and a method for coverage prediction have been provided wherein the aforementioned disadvantages associated with prior art arrangements have been substantially alleviated.

Claims

1. A method (300) of determining a per-cell coverage area in a cellular communication system that comprises multiple cells, the method characterised by the steps of:

receiving measurements of one or more parameters relating to one or more operations of a first cell in a cellular communication system, wherein said one or more parameters includes information relating to whether a wireless subscriber communication unit can be served by a number of cells or uniquely served by the first cell; and calculating (310, 315) a degree of coverage overlap based on a number of said measurements.

2. The method (300) of determining a per-cell coverage area in a cellular communication system according to Claim 1, the method further characterised by the step of partitioning (310) said measurements into one or more of at least three categories with respect to a target cell, wherein:

(i) A first category is where the measurement relates to a wireless subscriber unit that is uniquely served by a target cell,

(ii) A second category where the measurement relates to a wireless subscriber unit that can be served by a number of cells, and

(iii) A third category where the measurement relates to a wireless subscriber unit that is served by a neighbouring cell but could be served by a target cell.

3. The method (300) of determining a coverage area in a cellular communication system according to Claim 1 or Claim 2, wherein the step of calculating (310, 315) a

degree of coverage overlap based on a number of said measurements employs a statistically valid sample of said measurements.

- 5 4. The method (300) of determining a per-cell coverage area in a cellular communication system according to any preceding Claim, wherein the step of calculating (310, 315) comprises determining an unique coverage factor (UCF) for that cell, where:

1 0

$$\text{UCF} = \frac{\text{Sum of MRs with no and/or weak neighbours}}{\text{Total Sum of MRs}}$$

- 1 5 5. The method (300) of determining a per-cell coverage area in a cellular communication system according to any preceding Claim, the method further characterised by the step of:

2 0 converting (315) a number of measurements to Erlangs to determine a coverage overlap based on subscriber traffic within said cell.

- 2 5 6. The method (300) of determining a per-cell coverage area in a cellular communication system according to any preceding Claim, the method further characterised by the step of:

allocating a priority, for example an alarm priority, to said cell based on said calculation.

- 3 0 7. The method (300) of determining a per-cell coverage area in a cellular communication system according to any preceding Claim, the method further characterised by the step of:

re-configuring (335) an operational parameter of said cell, for example a transmit power, a beam-forming antenna tilt or direction, or turning off a cell, in response to said calculation.

5

8. The method (300) of determining a per-cell coverage area in a cellular communication system according to any preceding Claim, the method further characterised by the steps of:

1 0

storing said calculations; and
using (330) said stored calculation subsequently to determine a cell outage strategy.

1 5

9. The method (300) of determining a per-cell coverage area in a cellular communication system according to any preceding Claim, wherein the steps of measuring and calculating are used in an automatic frequency planning operation of said cellular communication system.

2 0

10. The method (300) of determining a per-cell coverage area in a cellular communication system according to any preceding Claim, wherein the wireless communication unit (146) receives measurement reports from a wireless serving communication unit, for example a base transceiver station (122-132), or a wireless subscriber communication unit (112-116).

2 5

11. A storage medium storing processor-implementable instructions for controlling a processor to carry out the method steps of any of claims 1 to 10.

3 0

12. A communication system (100) adapted to facilitate the steps of any of method Claims 1 to 10.

13. A communication unit (146) adapted to perform the steps of any of method Claims 1 to 10.

14. A communication unit (146) for use in a cellular communication system that comprises multiple cells, the communication unit (146) comprising:

1 0 a receiving function for receiving measurements of one or more parameters relating to one or more operations of a first cell in said cellular communication system; and

1 5 a processor, operably coupled to said receiving function, to process said received data, the communication unit characterised in that said processor calculates a degree of coverage overlap based on a number of said measurements.

2 0 15. The communication unit (146) according to Claim 14, further characterised in that said processor processes said received measurement data and partitions said received data into at least one of three categories with respect to a target cell, wherein:

2 5 (i) A first category relates to a wireless subscriber unit that is uniquely served by that target cell,

(ii) A second category where the measurement relates to a wireless subscriber unit that can be served by a number of cells, and

3 0 (iii) A third category where the measurement relates to a wireless subscriber unit that is served by a

neighbouring cell but is located such that it could be served by the target cell.

16. The communication unit according to Claim 14 or
5 Claim 15, wherein said processor determines an unique coverage factor for a cell (UCF), where:

$$\text{UCF} = \frac{\text{Sum of MRs with no and/or weak neighbours}}{\text{Total Sum of MRs}}$$

- 1 0 17. The communication unit according to any of preceding Claims 14 to 16, wherein said processor converts a number of measurements to Erlangs to determine a coverage overlap based on subscriber traffic within said cell.

- 1 5 18. The communication unit according to Claim 17, wherein said processor allocates a priority, for example an alarm priority, to said cell based on said calculation.

- 2 0 19. The communication unit according to any of preceding Claims 14 to 18, wherein said communication unit or a unit operably coupled to the communication unit re-configures one or more operational parameters of said
2 5 cell in response to said calculation.

20. The communication unit according to Claim 19, wherein said communication unit configures said cell for transmit power changes, beam-forming antenna changes,
3 0 and/or switching off said cell site.

21. The communication unit according to any of preceding Claims 14 to 20, wherein said communication

unit is an operations and management centre (146) configured to receive measurement report data relating to cells in said cellular communication system.

5 22. The communication unit according to any of preceding Claims 14 to 21, wherein said measured data includes one or more of the following:

- 1 0 (i) Cell statistical information, for example in the form of Congestion, Blocking, Mean-Hold Time (MHT), Handover (HO) Cause distribution information;
- (ii) One or more Measurement Reports; or
- (iii) Control Signalling behaviour.

1 5 23. The communication unit according to any of preceding Claims 14 to 22, wherein said processor is operably coupled to a memory device for storing said calculations for subsequent use in determining a cell outage strategy.

2 0 24. The communication unit according to any of preceding Claims 14 to 23, wherein said communication unit is able to communicate on a GSM, GPRS, UMTS, iDEN, or CDMA cellular communication system.

2 5 25. A communication system substantially as hereinbefore described with reference to, and/or as illustrated by, FIG. 1 of the accompanying drawings.

3 0 26. A method of determining a coverage area in a cellular communication system substantially as hereinbefore described with reference to, and/or as illustrated by, FIG. 3 of the accompanying drawings.

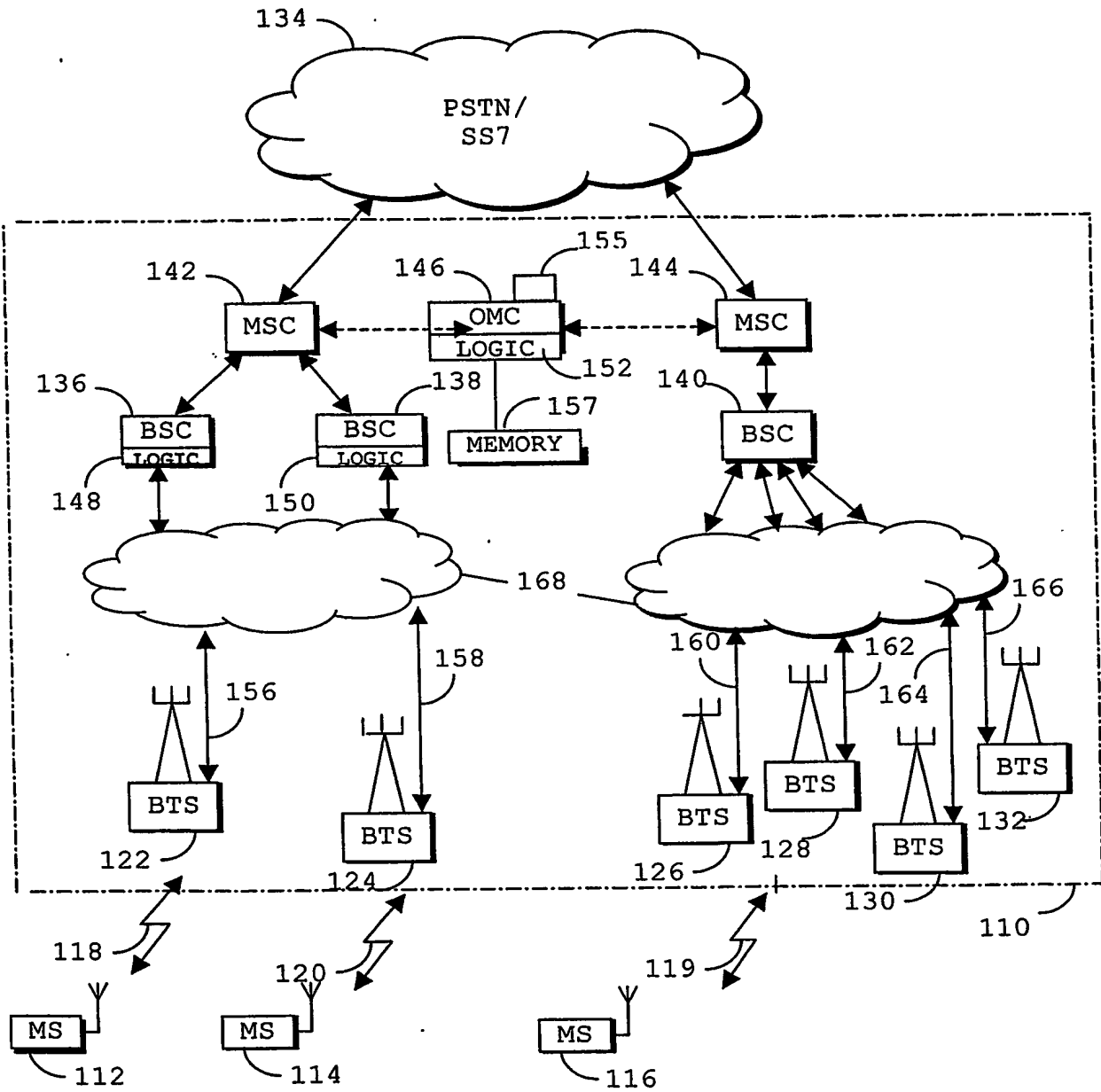
Abstract**METHOD FOR DETERMINING A COVERAGE AREA IN A CELL-BASED
COMMUNICATION SYSTEM**

5

A method (300) determines a per-cell coverage area in a cellular communication system that comprises multiple cells. The method comprises measuring (305) one or more parameters relating to one or more operations of a first
1 0 cell in a cellular communication system. The method includes calculating (320) a degree of coverage overlap from a number of measurements, preferably by comparing a number of first measurements relating to a location that is uniquely served, with a number of second measurements
1 5 that can be served by a plurality of serving communication units. In this manner, it is possible to determine an amount of overlapping coverage area based on real network measurements rather than inaccurate predicted data that has been traditionally employed.
2 0 Preferably, the measurements are converted to Erlangs to provide a coverage overlap based on subscriber traffic. A communication system (100) and a communication unit (146) are also provided.

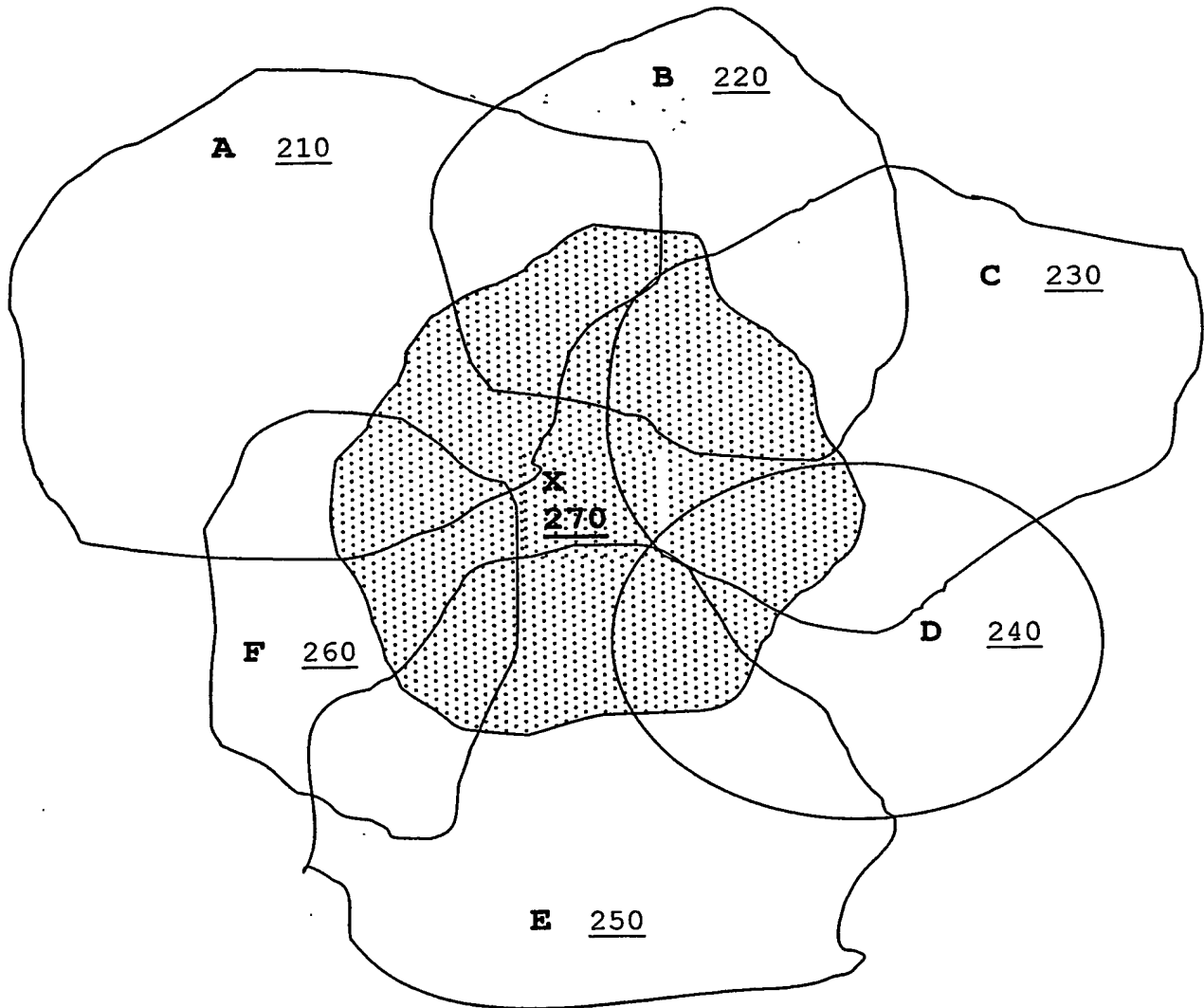
2 5 {FIG. 3 to accompany abstract}

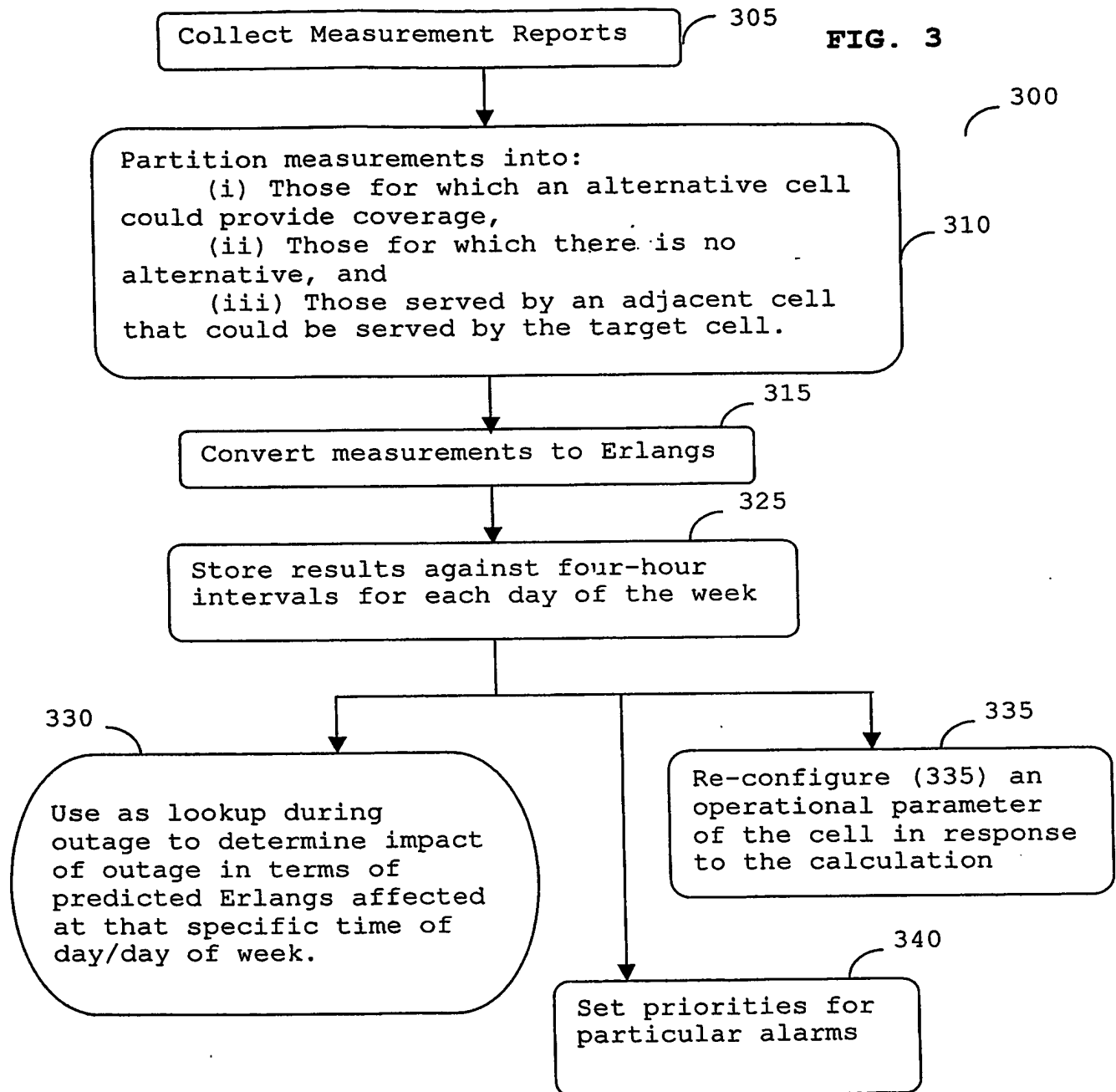
100
FIG. 1



200

FIG. 2





EP 04 50245

